Chapter 4

The Pursuit of Science in a Globalized Market: An Approach to Internationally Collaborative Science through Research Abroad Programs

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The past decade has brought about a wave of globalization, which has affected everything from business to education. In the education sector, many programs have adapted to globalization by incorporating study-abroad components into their curricula. However, academic science in the United States has notoriously resisted the push to adopt a more internationalized approach to educating its students, and continues to do so to this day. Particularly at the graduate level, American students are reluctant to study abroad, which may have a drastic impact on the future of science in America. As a participant in the National Science Foundation's East Asia and Pacific Summer Institute fellowship program, I was able to experience many of the advantages a science graduate student stands to gain as they take their thesis to another country. Recognizing that a research abroad experience also comes with its risks and difficulties, much of the material presented here aims to facilitate and clarify the process of identifying and completing study abroad programs for science graduate students. These students, in turn, will be in a better position to help the field of science overcome many of the barriers currently hindering scientific progress.

If you are a graduate student in America, look around you. Chances are, you have become aware that nearly 40% of physical science graduate students in the

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United States are international students (*1*). In certain fields, this proportion can be even larger. As a graduate student in Chemical Physics at the University of Illinois, I am well aware of the large foreign graduate student population here in the United States. Between the 8 members of our lab, we hold passports from 9 different countries, and speak over 10 different languages. However, I rarely thought about the effect studying abroad must have on graduate students. Furthermore, when so many of the world's graduate students opt to pursue graduate study outside of their home countries, why do American graduate students appear hesitant to do the same? One might think students would seize the opportunity to spend time in an exciting and perhaps even exotic foreign country. On the other hand, those same students are fully engaged in completing thesis projects and might perceive international graduate research experiences as "speed bumps" on their way to a graduate degree that may slow down their graduation timeline. Those students fail to appreciate that some of the program's greatest benefits are not immediately apparent.

One possible reason for graduate student hesitation towards studying abroad is that the high quality of graduate school in American universities makes it more attractive for foreign students to come here as opposed to American students studying abroad. While the United States is a global leader in many aspects of academic science, it is far from being the only scientific powerhouse in the world. For example, many nations such as China are emerging as future scientific frontrunners (*2*). Moreover, many areas of research are more easily performed in certain geographical locations due to local conditions that would be best studied on-site, such as research on geographically confined diseases (*3*). Lastly, and perhaps most importantly, research abroad provides insights into how other nations, cultures, and people approach scientific problems, allowing graduate students to be better prepared for jobs in a workforce that has become increasingly globalized. This begs the question: Why don't we see more American graduate students abroad? If not for an entire graduate degree, why not for a year? Or a semester? Or a summer?

One of the key reasons many American graduate students hesitate to go abroad must be due to the lack of information, particularly first hand anecdotal information, on the overall impact of studying abroad at the advanced education level. In an effort to fill that void, I will provide some feedback from my personal experience as an NSF East Asia and Pacific Summer Institute (EAPSI) summer research fellow at the University of Osaka in Japan. I will focus on how this experience helped shape my graduate career, and discuss tips on how to prepare for it so as to maximize your research productivity. I will discuss the *whys* of international research experiences for graduate students in the sciences, and how they have the potential to shape you and your career. Lastly, I will discuss how these international experiences benefit the scientific community as a whole by allowing you to become involved in breaking down barriers to cross-cultural exchange first-hand. Let this serve as a rough guide for how you, as a graduate student in the sciences, can become part of an increasingly large network of internationally driven science in today's globalized society.

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A How-To Guide for the Aspiring Study Abroad Graduate Student

The National Science Foundation's EAPSI fellowship is a fantastic opportunity for American graduate students wishing to perform research abroad and establish long-lasting international collaborations. To apply, one is required to submit a research proposal for a project to be completed in collaboration with a laboratory in one of seven locations: China, Japan, Taiwan, Singapore, Korea, Australia, or New Zealand. To make the most of a graduate research exchange program, you will need to quickly adapt to a new culture, location, and language while performing research in a manner that will allow you to form long-lasting scientific collaborations. This is not an easy task. Much effort is required on your behalf to ensure that international research opportunities will yield optimal results, and that your time away from your home institution will be used to propel your thesis work and research interests. In an effort to help the aspiring graduate study abroad student, I will be candid in outlining the tasks I did (or wish I had done) in the preparation and execution of my research experience at Osaka University through the EAPSI program. This will help ensure a successful experience abroad while minimizing the probability of disrupting your graduate studies.

i. Identifying a Scientific Question

First and foremost, it is important to identify the scientific question one wishes to address in collaboration with a foreign laboratory. For many graduate students, applying for an international fellowship may be the first time the student independently writes a research proposal. Make sure that your proposed research project is directly relevant to your current research, and that the laboratory specializes in techniques and/or projects that will help propel your graduate career.

When drafting your research proposal, it is important to be realistic with regards to your research time frame. Many fellowships for international research such as EAPSI are short-term (a few weeks or months). It is important to consider this time frame as a fundamental limitation to your research proposal, and incorporate it blatantly in your application. However, in many cases it may be possible, and it would certainly be beneficial, to extend your research abroad into a long-lasting international collaboration between your home and host laboratories after your return. If this is a foreseeable consequence of your proposed research collaboration, stating it in your proposal will strengthen your overall application.

ii. Funding Your International Research Proposal

Once the scientific question has been identified, it is then necessary to find a funding source or a fellowship program to support the proposal. There are many funding sources for U.S. graduate students who wish to perform research abroad, varying in geographical location, funding amount, and program duration. The program in which I participated, NSF-funded EAPSI, ran from 8 to 10 weeks depending on the host country (*4*). Several other NSF-funded international

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fellowship programs exist, such as CESRI (Central Europe Summer Research Institute), and the Nordic Research Opportunity for NSF Graduate Research Fellows (*5*, *6*). For longer-term support, Fulbright fellowships are available for graduate students, post-docs, and other academics (*7*). Most of these fellowships require a scientific collaboration to be pre-established between the student and a host laboratory, and this must be explicitly stated in the fellowship application.

iii. Finding an International Host Laboratory

During the preparation of your application, you must concurrently identify potential collaborators and host laboratories that might help you realize your reasearch proposal. This potential for collaboration weighs heavily on the success of your application, and it is unfortunately one of the more difficult steps of the application process. In most cases, your soundest source of guidance for finding a host laboratory will be your graduate research advisor. Not only will your advisor have a better grasp of the intrinsic "feasibility" of your research proposal, but s/he will probably be better acquainted with other researchers in your field, and will be in a better position to suggest potential hosts.

It is also useful to consult with other lab members, or other scientists in your field. If time allows for it, prior to applying for international research fellowships, attend conferences in order to become more familiar with the work being done in your field. Moreover, the opportunity to speak with scientists about possibly establishing a collaboration is much easier to do face-to-face versus via e-mail.

You should also compose a short draft of your proposed research project and attach it to any correspondence that is sent out to potential hosts. In many cases, the host's primary language may not be English. While most science around the world is performed and published in English, individual researchers and even PIs (Primary Investigators) may not be as well-versed in the English language as their publications may suggest. For this reason, it is important to keep communications with the potential host laboratory as simple as possible, avoiding jargon and lengthy sentences while clearly communicating the goal of your potential visit. Once positive responses from potential hosts are received, they should be included in the fellowship application.

iv. Pre-Departure Preparation

Once funding has been awarded for your abroad research proposal, it then becomes necessary to prepare for your lab visit as thoroughly as possible prior to your departure. Prepare as much as you can before you leave, both scientifically and culturally.

If your host lab is located in a country whose language you do not speak, it is worth investing some time in learning key phrases you will need during your stay. Many countries, such as Japan, have higher standards for work etiquette than you will typically find in the United States (*8*). In my case, this made it imperative for me to know Japanese phrases that were necessary to show respect and a positive work attitude in lab. Every morning, saying *ohayo gozaimasu* (good morning, formally) was important. Since meals were often eaten with fellow lab members,

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knowing to say *itadakimasu* (I gratefully receive) before a meal and *gochisosama* (thank you for the meal) afterwards was also crucial. Being aware of cultural differences aside from language will also help minimize culture shock or gaffes on your part. Although cultural differences such as way of life, food, local traditions, etiquette and such are best learned on-site, it can't hurt to do a quick Google search for "[country name] traditions" in preparation for your program. It might have helped me avoid the awkward handshake/bow blend I ended up performing while meeting my host advisor for the first time.

Finding accommodation for the duration of your program can be difficult, particularly from across the globe. Personally, I underestimated this feat and it is something I wish I had done in a much timelier manner. While my accommodations ended up being spectacular, that was due more to serendipity than to careful planning. Most programs will provide assistance on finding accommodation for you, and some will have already arranged your accommodations. In other cases, your host laboratory will help you find housing. But in some cases, finding accommodation may be left entirely in your hands. If the latter is the case, I encourage you to communicate with your host laboratory and have them help you make these arrangements.

My case was a bit out of the ordinary. The international dorms where visiting students were typically housed were under renovation, and the only other option for on-campus housing was a fairly expensive hotel. I opted to take a non-conventional and slightly riskier route to finding housing: Craigslist.com. It is here that I found two young Japanese women looking for a third to share their quaint roof-top apartment in downtown Osaka. This option had many downsides: the commute to campus would be over 1 hour each way, and I had no way of checking the validity of this housing offer since it was uncertified. However, I decided to take a chance, and spent my summer with two absolutely wonderful Japanese women in the heart of the historic "tenjinbashisuji roku chome" district of downtown Osaka.

On a side note, if you do find housing on your own be sure are confident in your ability to locate your new home, especially if this is your first time in this new country. On my very first night in downtown Osaka, I struggled to find my new apartment. I thought I had been clever and cautious, printing out a detailed map of my new neighborhood with instructions on how to find my apartment. Building 4, apartment 1010. However, I found myself amidst row upon row of identical high rise apartment buildings. Furthermore, the numbering system was unlike anything I had seen elsewhere in the world: I later learned buildings were numbered according to when they had been built, not in ascending order along the street. There were several buildings marked 4 in the block. It was dark, and although Japan is renowned for its safety, I panicked as I dragged my two suitcases through mazes of buildings for what seemed like hours. Without a phone, and with only "professional laboratory" Japanese phrases with which to communicate, I felt desperate as I sat on the side of the street and tried to calm my nerves. Embarrassed, I stopped a passer-by to borrow a cell phone and call my roommate (whom I had yet to meet) by means of an elaborate game of charades. The feeling of relief as she came to fetch me on the street corner was unprecedented, and greeted me with a consoling hug rather than the traditional Japanese bow. The best way to avoid

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this? Kindly ask a member of your host laboratory (or roommates, if applicable) to meet you at your arrival port or station, and show you the way home.

You must also prepare "scientifically" for your abroad research. This type of preparation will be the most influential in determining the success of your research project. If you have not, by this point, thoroughly outlined your research plan for the summer, do so now. Most of this information should have been included in your research proposal, as well as the communications sent out to your potential host laboratories. But now is the time to break apart this research proposal into two main sections: what can be done in your home laboratory, and what must be done abroad in your host laboratory. Anything that can be done prior to your departure should be done now, since you will want to start on your summer project as soon as possible upon arrival in your host laboratory. In my case, this involved making 3 months' worth of my DNA substrates and shipping them to my host laboratory in Osaka prior to my departure. Now is also the time to communicate with your host laboratory about your personal expectations for scientific progress over the summer. In many cases, you may be assigned to work with another student or post-doc in the lab. It is fine to ask your host to suggest a person in the lab with whom to work. Keep a steady stream of communication with this lab member between now and your departure. Initially, send this person your research proposal, as well as any relevant literature pertaining to your project. In some cases, the fellowship program in which you participate may provide your host laboratory with a small amount of funding to cover laboratory expenses you may incur during your research experience. If this is the case, you should also communicate with your contact person about any laboratory equipment you may need for your project. If possible, request to have this equipment ordered prior to your arrival, so it will be at your disposal as soon as you arrive. In addition to communicating about research equipment, you should clarify whether you will need any training to use the laboratory equipment of your host laboratory. If so, you will need to factor this training time into your research plan. From your communications with your host person, try to gauge how much independence you will have in the lab and plan your work accordingly. Additionally, be sure to research and learn about any techniques and instruments you will need to use, but with which you are currently unfamiliar.

Lastly, ask program hosts (in the case of EAPSI, Japanese administrative contact personnel were made available via e-mail) if there are any particularities about the host work environment of which you should be aware. In the case of Japan, it was important for all career-oriented individuals, students included, to carry business cards on their person. Moreover, the manner in which these business cards were exchanged carried an extensive set of rules as well. For example, upon meeting a new colleague, the more "highly ranked" individual should be the first to offer their business card. Upon being presented with a business card, one had to study it carefully before putting it in their shirt pocket or purse. Putting the business card into pant pockets was seen as disrespectful, since it symbolized insolence towards the owner of the business card. The "lower ranking" individual then reciprocated, by offering their business card. Additionally, each time a business card was exchanged, both members involved in the interaction would bow, and business cards had to be presented with both

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hands holding the card. EAPSI program participants practiced this ritual several times during our training sessions, since it was a particularly important facet of the Japanese work environment. To be in a position where one was not able or willing to reciprocate the exchange of business cards is an enormous insult to the business card offeree. I was able to order business cards online, one side in English and the other in Japanese. I contacted students in my University's Japanese language program as well as fellow Japanese graduate students for help in translating my business card information.

Acquiring all of this information is time consuming, and often difficult, particularly if you and your host laboratory experience a language barrier. However, the time and effort it will save during your research experience is invaluable. Moreover, it will also help the members of your host laboratory prepare for your arrival, and will allow them to accommodate your project into the preexisting structure of their laboratory.

v. During the International Research Program

Now the fun begins! As soon as you step off the plane to your host country, I can guarantee that you will feel the rush of adventure, particularly if you have prepared well for your research experience. In my case, the first week after landing in Japan was spent in Sokendai, an academic campus south of Tokyo. It was here that the American EAPSI program participants met the other student participants from France, Canada, Great Britain, and Germany. Collectively, we became known as JSPS (Japan Society for the Promotion of Science) fellows, as our summer research program was co-sponsored by JSPS, a Japanese national science funding agency. We underwent a week-long "cultural acclimatization" orientation which included Japanese language crash courses, as well as a 2-night home-stay with a local Japanese family. Such on-site orientation sessions are common for abroad research programs, and are particularly helpful for students being hosted in countries with very different languages and/or cultures than one's own. The materials presented are typically tailored to preparing students for the professional laboratory environment of their host countries.

After this week-long orientation session, we each made our way to our host laboratories. I spent the latter half of my bus ride from Tokyo to Osaka practicing the handful of Japanese phrases I had learnt for the purpose of introducing myself to my hosts. My first day in the laboratory, I met my host PI and a few of the lab members. Amongst these 50 lab members were two other "gaijin" (foreigners), a rare sight in a scientific community heavily populated by, well, Japanese. In fact, "gaijin" presence was scarce in all of Osaka. On several occasions I noticed locals covertly taking pictures of me and my other "gaijin" friends with camera phones on the metro, a term we quickly dubbed as "gaijin-hunting". Funnily enough, though my host laboratory in Osaka spanned the entire building floor, I was assigned a desk right next to the only two other "gaijin", possibly as an effort on behalf of my hosts to make me feel more at ease.

On the first day, I felt hesitant to delve into my lab work immediately since I was a new and temporary student. I was surprised when nobody, including my "host contact person", helped me get started at the bench. While I did catch a few

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lab members' curious peeks towards my desk, my interaction with others remained minimal during the first few days in my new lab. I was pulled aside by a fellow "gaijin" lab mate who explained the cultural differences that might have made my frist day so awkward. First of all, as a Hispanic-American female chemical physicist, I created a very unusual presence in a Japanese physics laboratory. Not only are most Japanese scientists male (*9*), but non-Japanese scientists are few and far between (*10*). In fact, amongst the 50 or so scientists in my host laboratory, I was the only female graduate student, and one of only two foreign graduate students. However, the main cause of my discomfort stemmed from the inherent cultural differences for hosting new students. I learned that Japanese customs err on the side of independence when dealing with a new worker, and that I would have to initiate any help or training. In Japan, being proactive is seen as a trait that typically brings social discomfort, and is often seen as disrespectful in teaching scenarios.

For example, had my new senior lab mates given me a training schedule to learn to use the lab's instruments, this would have implied that I was deemed unknowledgeable or academically inferior to them. Instead, I was expected to seek advice from my peers as I encountered difficulties while independently adjusting to my new laboratory environment. Being unaware of these cultural customs, I refrained from seeking help from my new peers, worried I would be an unwelcome disruption to their everyday tasks. Meanwhile my Japanese hosts had done much of the same, out of respect for my scientific independence. Once made aware of this difference, I began rummaging around the lab for my materials, familiarized myself with the new instrumentation, all while asking my host lab mates for help whenever I encountered difficulties. I was spared the "learning experience" that my fellow "gaijin" lab mates underwent: One admitted to having wasted several weeks at the beginning of his abroad research experience waiting for his Japanese hosts to help him start a project. In the meantime, his Japanese hosts wondered why he didn't work, and why he did not come to them for help.

The point of this anecdote is to highlight how much influence cultural differences can have on your lab work, and on your overall research experience. While many westernized work cultures implement a "old teach young" approach for new hires, in Japan new students are treated the same as veterans, and it is up to the new student to seek help whenever (s)he encounters a problem. This can obviously create some productivity conflict if you are not aware of these unspoken cultural differences, and particularly if you are alone in encountering them. I would suggest for you to contact former participants of your abroad research program. The EAPSI program has a mandatory 3-day pre-departure orientation in Washington, D.C. that gives EAPSI participants the opportunity to meet EAPSI alumni a few months prior to embarking on their summer research experience. However, if your program does not offer such an opportunity, find some past participants of your program that are willing to share their personal experiences and the hardships they encountered for overcoming the cultural barriers in a foreign laboratory setting.

Throughout your research experience, but particularly during the first few days, observe the interactions between group members, and try to identify cultural differences in these interactions. The manner in which people interact,

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the laboratory tasks assigned to individuals, the level of formality and the style of dress (casual, business casual, etc.) of the lab members, work schedules, work expectations, and punctuality are but a few examples of what you should try to observe. Try to follow these cultural norms, not so as to assimilate to the host culture, rather out of respect for your hosts. It pays to be culturally aware of the differences in interpersonal interactions and scientific methodologies of your host country. While your host lab members will probably be lenient in not expecting you to know all of their cultural etiquette, they will very much appreciate you making an effort to identify and follow it.

As an American graduate student in the sciences, you are probably fairly accustomed to being in a nationally and culturally diverse school setting, as shown by the large percentage of international students at the graduate level (*1*). However, keep in mind that these same circumstances may not hold true for other nations such as Japan where foreign students are rare (*10*). They may be curious, inquisitive, and perhaps put somewhat on edge about having a foreign graduate student visitor, particularly if you are a female in a male-dominated field (*9*). On several occasions, I walked into a room where my male lab mates had been fraternizing, only to hear conversations being hushed immediately upon my arrival (ironically, as I did not understand Japanese, anyway). I later learned that certain topics of conversation (dating, personal lives, nightlife plans etc) are not "appropriate" to be discussed in the presence of female co-workers, and that doing so would be considered disrespectful. My Japanese lab mates, in these instances, had been trying to maintain their respect for me and the professional relationship that we had. Meanwhile, I had felt awkward and a bit left out during these occurrences. Similar situations occurred to a fellow EAPSI participant, based in China. She spent the entire 8 weeks of her program never having established communication with a lab mate with whom she shared a lab bench. Initially she assumed her attempts at conversing, and his blunt one-word replies, had been personal attacks against her character. However, she later learned that this lab mate was very self-conscious about his English speaking skills, was exceptionally intimidated by her presence, and was therefore reluctant to "shame himself" by attempting to speak English at a much lower level than her spoken English skills. It is of upmost importance to realize that you may be entering into a setting in which your new lab mates will not be accustomed to interacting with foreigners. Keeping a high level of cultural sensitivity during these times will put your lab mates at ease, and will facilitate the transition for them and for you.

One of the most effective ways of introducing yourself and your work to your laboratory is to give a short group meeting presentation on your personal and professional background. Ask your host advisor if this is feasible. Give a short PowerPoint presentation about your home academic institution, perhaps a few words on your personal interests, your research background, and what you hope to accomplish during your abroad research visit. "Putting it all out there" in this setting, early in your visit, will take the pressure away from future interactions with your lab mates. Furthermore, making your lab mates aware of your previous research experience may make them aware of any help you might need during your research visit, and might make them more willing to offer their expertise.

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Once you feel you have established yourself in your lab, take some time to explore your new surroundings! For most EAPSI 2009 participants, the EAPSI program was the first time they had set foot in their host countries. Traveling within your host country is beneficial on two fronts: Firstly (and obviously), it gives you the opportunity to explore a new country. Secondly, it may give you the opportunity to meet other researchers and their labs. This can help increase your professional network within your host country and within your field. In fact, JSPS provided a substantial amount of money for JSPS summer research fellows to travel within Japan to meet other PIs and take tours of other labs. If you chose to do this (and I would strongly encourage you to do so), you can try to contact other labs within your host country prior to your departure, and ask if they would be willing to meet with you. Alternatively, you can ask your host research advisor if there are any local conferences that you may attend during your stay, or if (s)he has any colleagues in the field that (s)he feels you could benefit from meeting.

Lastly, just relax and make the most of this unique opportunity. Talk to other members of your graduate research exchange program (if applicable) if you get overwhelmed, and be sure to communicate any serious problems or concerns with program staff. And keep in mind, in the midst of your excitement while experiencing new foods, people, and places, that the worst of the culture shock typically occurs when (*11*)…

iv. You Return Home

This was certainly the case for me, and for many other EAPSI participants with whom I spoke after returning to the United States. Before embarking on my EAPSI adventure, I was told that reverse culture shock (i.e. the culture shock upon returning home) was much more severe than the culture shock of arriving in your host country. In my case, this statement could not have been more accurate.

For me, the process of re-acclimatization began with the tearful good-bye I shared with my two Japanese roommates at the base of Mount Fuji. It was also difficult to bid farewell to my host lab mates, who had helped me realize a significant part of my doctoral thesis. Culturally, there were also many aspects of Japanese culture I had grown to love, admire, and I had adopted as part of my everyday life. These ways of life also contributed to the reverse culture shock upon re-entry into the United States.

In Japan, respect for others, politeness, gratitude, and above all, integrity were traits held in the highest esteem for all: from the McDonald's cashiers who bowed, smiled, and profusely thanked every customer, to the Osaka University professors who instinctively bowed while talking to colleagues over the phone, I always felt respected and safe, never once felt threatened, mistreated, objectified, or endangered during my stay in Japan. In fact, when returning home early one morning after a night-long *tenjin matsuri* (annual local festival in Osaka), I spotted a man sleeping outside on a public park bench. He was dressed in his work clothing, and beside him were a neatly stacked pile of coins, bills, his mobile phone, and his keys. No doubt, he had removed these items from his pockets and had put them on the ground beside his bench, so as to sleep more comfortably. Nevertheless, it had never occurred to him that somebody would

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steal these items, because of Japan's low crime rates. Travel books constantly remark how astoundingly safe Japan tends to be: One particular travel book quotes the story of a tourist who forgot his camera at a popular Japanese tourist site. He returned the next day to find his camera at exactly the same location, untouched and unharmed. In my case, one of the most immediate elements of culture shock stemmed from how deeply I had become accustomed to this way of life. Upon returning home, I felt unusually repulsed by the gruff manner with which my bus driver demanded for exact change, by the apathy with which the librarian renewed my library books, I felt unusually paranoid walking home after dark, I mistook strangers' smile-less glances as forewarnings for aggression. I missed fresh sashimi, my Japanese friends and lab mates, I even missed being illiterate and being unable to understand the incoherent melody of the Japanese language in my surroundings. Gradually, I began to realize that these feelings were but mere reactions of my acclimatization to the Japanese culture. The bus driver wasn't being rude, the librarian wasn't apathetic, and nobody was out to get me during my walk home. Humans are beings of habit, and we respond strongly to changes in our environment. In fact, it isn't unusual for study abroad veterans to think more critically about their home cultures and societies upon their return home (*12*, *13*). This type of critical thinking, I would strongly argue, could help us all create better societies by adopting positive attributes from different cultures from around the world.

Lastly, upon returning to your home institution, you should make efforts to continue communication (and, even better, collaborative research) with your host institution. To this day, I occasionally participate in "language and science exchange" discussions with my Japanese lab mates over Skype. These hour-long discussion sessions are an exemplary medium to keep the lines of communication open between my home and host laboratory, and to continue the process of cross-cultural learning long after the exchange program has concluded.

I hope these tips and anecdotes will help you structure your research experience. It is no small feat, but the rewards that can potentially be reaped from a program such as EAPSI far outnumber the risks that plague the minds of many hesitant graduate students. With careful planning, an open mind, and a pocket translator, you can be ensured an academically and interpersonally successful abroad research experience.

Part 2: How Graduate Study Abroad Programs and International Experiences Lead to Increased Scientific Productivity

The United States is often seen as the global leader in all that is science, both at the academic and industrial fronts. International students contribute $12 billion annually to the American economy, making the US the leader in the field of international students of higher education (*14*). With America's stellar scientific reputation, and with its "dominance of the world higher-education market...", it is easy to understand why so few American students study abroad: 0.2 percent at the undergraduate level, and considerably less at the graduate level (*14*). Alarmingly,

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these rates are even lower, at all educational levels, for students of science (*15*). In becoming too comfortable at their home institutions, are American graduate students missing out on an essential part of graduate education?

Most of today's academic programs, from business to social work, are well aware of the effects globalization is having on their work forces. Many academic programs in these areas are beginning to incorporate mandatory international exchanges into their students' curricula, since students with international experience are likely to be considered better job candidates than their stay-at-home counterparts (*14*, *15*, *21*). Science being such an avant-garde field by nature, why are we lagging behind in the trend of academic internationalization?

When I was faced with the opportunity to participate in EAPSI, I was hesitant. I was hesitant to ask my PI if I could apply to EAPSI, I was hesitant to contact potential collaborators who might or might not have sufficient English proficiency to understand my emails, hesitant before clicking the "submit" button to my EAPSI application, I was hesitant when I accepted the award, hesitant throughout the pre-departure orientation, and hesitant as I boarded my 14-hour flight to Tokyo.

Primarily, I worried about my academic progress as I went abroad. It had taken me a solid year to get good lab results at my home institution, the University of Illinois. What made me think 10 weeks at Osaka University would be academically "profitable"? My decision to apply for an EAPSI fellowship was prompted by certain difficulties I had encountered during my Ph.D. thesis work. I had encountered two major hurdles, one stemming from instrumentation-induced photodamage to my samples (*19*), and the second stemming from observing unexpected behaviors of the biological system I study. I am interested in how certain proteins are able to identify a tiny DNA target sequence- usually only a few base pairs long- among thousands of base pairs of non-target DNA. Proteins are able to do so at surprisingly fast rates, and some, like the protelomerase protein I study, are able to do so without energy-rich cofactors such as ATP (*20*). This is analogous to finding your way to a new laboratory (like I had to do) in the middle of a very large foreign city (such as Osaka, Japan), in a car (without fuel, thankfully not my case) in a matter of minutes or seconds. However, I was having trouble extracting meaningful results from my data, and decided that I would need to approach my scientific questions in a different manner. I then was given the recommendation to apply for the EAPSI program, in order to take a different approach to solving my research hurdle. My goal was to image my protelomerase protein at a single molecule level, to visually observe its behavior during its interactions with DNA. Therefore, I contacted an expert in Total Internal Reflection Fluorescence Microscopy (TIRFM), Dr. Toshio Yanagida at Osaka University's graduate school for frontier biosciences, and asked him to be my EAPSI host researcher.

To say that my ten weeks in Osaka were a learning experience would be an understatement. New lab instruments, new culture, even a new circadian rhythm. Surprisingly enough, learning to operate TIRFM instruments was by far the easiest learning experience of the summer. First of all, I could not speak or read Japanese. This led me to make several mistakes only illiteracy could cause, such as eating my morning cereal with cream instead of milk, or accidentally washing my laundry in fabric softener instead of detergent. However, thanks to

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the astoundingly welcoming environment created by my Japanese lab mates and my Japanese roommates, I quickly became acclimatized to my summer living environment, and took advantage of this unique opportunity to be a graduate student in Japan. Somehow, in between my long days in lab, I had the opportunity to experience Japan's rich culture and history. I had the chance to visit each of my rommates' hometowns to celebrate Obon, a Buddhist holiday to honor one's deceased ancestors. I experienced the grueling 16-hour overnight hike to the summit of Mount Fuji. I got ambushed by the wild deer of Nara, and participated in the hectic annual city-wide festivals in Osaka and Kyoto. I took the high speed *Shinkansen* train to the volcanic cities in Japan's southern island of Kyushu. I even camped on the beach on Ikuchijima island with a handful of locals who spoke no English whatsoever, while attending a 2-day outdoor independent music festival not unlike a Japanese version of Woodstock.

These cultural experiences were fantastic, but the true tests of cultural aclimatization occurred in my host lab. In my Osaka University laboratory, I had to adapt rapidly to a new work environment, an environment dictated by a set of cultural laws with which I was unfamiliar. It was while recognizing and overcoming these cultural barriers that I learned the most useful cultural lesson of my summer as an international graduate student: Despite language and cultural barriers inherent in all cross-national exchanges, the drive for the pursuit of scientific discoveries is a universally upheld concept.

Recognizing cultural differences is instrumental for the success of any international research experience, but it is not an easy task. For the most part, a good approach to any new cultural environment is to play it safe and follow the lead. I observed interpersonal interactions between my new group members, and made mental notes of interactions that reflected Japanese culture. For example, it took but a few days for me to realize that interpersonal interactions in Japanese laboratories were much more formal than in the United States. Moreover, it became apparent that the laboratory had a rigid hierarchical structure, and that the level of formality with which one addressed another depended on the relative position of each person in this social hierarchy. For graduate students, deeper and longer bowing was necessary when greeting a post-doc or other senior level scientist. These observations were particularly important in group meeting settings, in which a lab member was presenting their work. In these cases, only group members considered "equal or higher" than the presenter in the laboratory hierarchy asked questions about the speaker's work. Even the laboratory directory at the entrance of the building listed lab members in order of their hierarchy within the laboratory. However, these social hierarchies actually made the laboratory more efficient and organized. Everyone knew their roles and tasks within the laboratory, and despite comprising over 50 members, everybody knew who to call on for help with experimental troubleshooting. Little time ever appeared to be wasted as everyone assumed their roles and their tasks from the moment they arrived in the laboratory, to the moment they stepped out. Much of this efficiency must have been due to the formal and hierarchical nature of the laboratory. It goes without saying that many laboratories across the world could benefit from taking pointers from Japanese laboratories, particularly in the realm of efficiency and cleanliness. If a seminar was to begin at eleven, *everybody* would be present

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at 10:55. If an instrument broke down, the person responsible for it would be quick to fix it. Everyone wore slippers in the lab, no shoes were worn past the laboratory entrance to keep it as clean as possible. And on Fridays at 10, without exception, all group members would abandon their current tasks, pick up vacuum cleaners, mops, and brooms, and clean the entire lab. I had never observed a more smoothly-running laboratory. It was more of a science factory than what I had come to know as a laboratory.

As time went on, I became keener to the differences in how Japanese labs function. I began to think more critically about some of the laboratory practices I had developed, and was able to merge my protocols with new ideas from my host laboratory; protocols that I still utilize to this day. Additionally, my experience abroad allowed me to "open doors" for my academic future. As a JSPS fellow, I was presented with an array of other opportunities to continue my studies in Japan after I will have completed my doctoral degree. JSPS offers very lucrative fellowships for post-doctoral researchers, as well as fellowships for professors who wish to spend some time teaching and researching in Japan. From what I was told by my host lab mates, the Japanese government has realized the need for internationalization of its scientific workforce, and has put fourth many incentives to diversify it. As such, I became aware of career opportunities outside of the United States. Moreover, I was able to establish a network of contacts within Japan, such as my host research advisor who invited me back to his lab for a post-doc. This type of networking would have been impossible to accomplish without being on-site, where my Japanese PI and colleagues were able to observe my work ethic, skill set, and productivity first hand. While reflecting upon all that I had personally gained during my time at Osaka University, I began to realize how dependant all of these learning experiences had been to me being away from my home country, out of my ¨comfort zone¨ so to speak. For this very reason, it struck me as odd that these types of international research experiences aren´t more ubiquitous amongst American graduate students.

While in Japan, it also became clear to me that in any academic laboratory setting, the science is only half the battle. Proper management of students and post-docs by the PI, and the manner in which scientific questions are addressed are crucial aspects of a well-established laboratory. The science half is universal: The speed of light and sound, the pull of gravity, the value of absolute zero temperature, the number of moles in a liter of water; all of that remains (to a reasonable approximation) the same whether you are studying these phenomena in Brazil or Sri Lanka. However, the *manner* in which these scientific questions are taught, learned, and researched varies greatly from laboratory to laboratory, and varies even more so from culture to culture. Teaching, learning, and researching are all socially structured and culturally driven approaches used to delve into the universal scientific questions we all wish to answer. Every country and culture approaches science in a different manner. And because there are strengths and weaknesses to all of these approaches, international exchanges allow students to sample these new approaches with open minds and bring home new ideas on how to advance science. I personally believe that the ability of members of the scientific community to 1- understand this and 2- work to use these differences productively through open minded collaborations, is directly proportional to the

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potential for the advancement of science on a global scale. One of the biggest challenges will be to encourage more American graduate students to pursue internationally collaborative research.

A mere 3 months at Osaka University was enough to convince me that there are certain learning experiences that simply cannot be acquired unless one ventures outside their home country. For one, students who spend a certain amount of time studying abroad will be exposed to that country's cultural environment, and will have to master the art of cultural tolerance and adaptation. These traits are crucial when dealing with a globalized workforce. But also, in dealing with cultural differences, students will naturally be introduced to the globalized nature of science first-hand. Students will find that while culture may dictate many aspects of their study abroad experience, science shares many universal traits. After all, science, unlike other markets such as business and politics, is not a product of an environment created by humans; rather science is inherent to nature thereby making it universal by default.

Learning to identify- and adapt to- cultural differences should be an integral part of every student's education. Research abroad experiences, particularly at the graduate level, provide students with an unparalleled medium in which to learn 21st century professionalism. Coming back to the idea of globalization, much emphasis is being placed on the ability of young professionals to interact with international members of their field in a professional manner. Such social and professional skills cannot be classroom- taught, and must be acquired (sooner rather than later) through interpersonal interactions. Markets have become increasingly responsive to the diminishing importance of national borders, and students within these markets must make the necessary adaptations to keep up with the changing times. I just hope that with all of America's stellar science, reputable graduate programs, and top- notch research institutions, American graduate students will not be left behind in the push for globalization to unify science on all national fronts.

Lowering Barriers to Cross-Cultural Exchange: Multi-Faceted Problems Require Versatile Solutions

Say you have a collection of 100 apples. Of these apples, 30 are fresh and crispy, 50 are mediocre, and the remaining 20 are old and rotten. If you are told to pick a harvest of 30 apples from this collection, without a doubt you would pick the 30 fresh apples every time. However, say you first take these 100 apples and randomly divide them into 10 groups of 10 apples. Once again, you are told to pick a harvest of 30, only this time you can only chose 3 apples from each group of 10. Statistically speaking, your harvest of 30 apples from the group of 100 will be better than the group of 30 selected by picking 3 apples from 10 groups. By imposing boundaries on the apples, you decrease the overall quality of your harvest, since some groups of 10 may have more than 3 perfect apples, and other groups of 10 may have no perfect apples for you to choose.

The same applies to science. Boundaries, whether they are national, political, socio-economic, racial, linguistic, or cultural, impose restrictions on the ability of

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the international scientific community to maximize its productivity. Now, some of these "boundaries", such as cultures or national borders, shouldn't be abolished in the name of science. Cultural differences, for example, provide the world with a necessary richness, and can even help advance science if approached properly. Personally, I enjoy taking part in new cultural traditions whenever I travel. I still remember my first trip outside of North America. I was 4 years old, and I went to Bolivia to visit my mother's family. As a 4-year old, I had a fairly limited understanding of culture. However, even from my eyes cultural differences became apparent, and I was in a constant state of amazement. Here, Christmas was smack in the middle of summer vacation. People lived mostly in villages or farms. People dressed differently; women wore colorful *cholita* dresses and often danced to traditional Bolivian music. The food was very different. When I returned home, I enthusiastically gave my kindergarten class a show-and-tell presentation on my experience. I told my fellow kindergartners about seeing wild alpaca, eating mango ice cream, and running myself nearly to exhaustion while playing a game of tag with my cousins 12,000 feet above sea level in the highest altitude capital city of the world, La Paz.

I felt 4 again when I landed in Tokyo. All of a sudden, not unlike my early years of life, I couldn't read, write, or speak (Japanese). I was amazed by the temples, the shrines, the women with kimonos, and the tea ceremonies. Centuries that shaped Japan as a country have allowed these cultural traditions to surface, a treat to experience for any tourist in Japan. And while some of these cultural differences, such as language, did pose difficulties for information exchange in my summer lab, it is these same cultural differences that make Japan such an interesting country to visit.

But cultures do much more than provide entertainment for tourists. Culture provides an overall structure for a country and influences everything from its laws to the religious views held by its citizens. Culture even shapes many ascpects of science. National and cultural dissimilarities need to be preserved and respected even if they might at times complicate the exchange of information. Therefore, in order to maximize the productivity of information exchange during- say- a summer research program in Japan, one must learn to work around these cultural differences in the lab while simultaneously learning to embrace them in every other aspect of their research abroad experience. Doing so is no easy task, but I found that making an effort to truly embrace a new culture during an international research experience allowed me to gain much more than new research techniques during my summer in Japan.

Culture must be preserved, yet it is the most prevalent dissimilarity that scientists will face during an international research experience. However, it can be used to the advantage of the scientific community if properly respected, learned, and even embraced. Over the course of my summer at Osaka University, I found that the extent to which my hosts were willing to accommodate me was directly proportional to the amount of effort I made towards learning and respecting Japanese cultural traditions. As a visitor in a foreign laboratory setting, your best bet is to keep an open mind about how a new culture will approach science. From eating moving octopus that was trying to escape from my dinner plate, to running my experiments using protocols I had never come across but were recommended

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by my new PI, I approached my international experience with an "I will try anything once" mentality. Though I never again ate a moving octopus, to this day I still implement laboratory techniques and protocols from my summer in Japan, techniques that I had never previously considered.

Furthermore, international exchanges automatically increase one's personal productivity as a scientist by amplifying the extensiveness of one's academic support network. By going abroad, I had the opportunity to share ideas with scientists outside of my immediate surroundings and I was able to gain a different perspective on how to approach my research. These experiences are doubtlessly beneficial to a graduate student's career, but cumulatively they increase scientific productivity on an international scale as well. Just as Charles Darwin noted that species evolve to acquire traits which allow them to best accommodate to their local environments, the manner in which science is performed has been optimized differently in each nation. Therefore, international research experiences allow members of one scientific community to experience alternate methods of approaching science. Subsequently, these new ideas are brought back to their home laboratories and become incorporated into their scientific repertoires, thereby increasing the overall productivity of the scientific community. Conversely, a scientist visiting a foreign laboratory will also bring in scientific tools and ideas from their home country, making international research exchanges rather symbiotic for both the home and host laboratories. In this manner, cultural barriers actually help science propagate, but only if scientists are willing to use these cultural differences to the benefit of science by actively participating in international research exchanges.

On the other hand, certain barriers to international exchange in the sciences are not advantageous. For example, barriers imposed on the scientific community by a country's economic or political standings can greatly stymie scientific progress.

Perhaps the most challenging, and therefore most frequently overlooked barrier, is the one formed by national borders and their corresponding politics. Political barriers are difficult to navigate, particularly because they are numerous and ever changing. Unfortunately tense political situations often dictate the degree to which scientific collaborations may be established between scientists of different nations. This leads to a lack of communication between scientists of these nations. Consequently, the extent of information sharing- which is crucial to the advancement of science- is compromised. Poor political influences can greatly limit the scope of scientific projects that are undertaken by scientists. We see examples of this everywhere. Venezuelan science has suffered greatly in the years of President Hugo Chavez, due to discrimination against or favoritism towards scientists based on political motivations (*21*). However, political scientific barriers are not strangers to top-tier research nations either, not even the United States. The stem cell funding ban imposed by President Bush in 2001 severely limited the amount and extent of research that could be done using embryonic stem cells, until the ban was lifted in President Obama's first term (*22*). Clearly, for an aspiring stem cell biologist, the United States might have been a questionable location to pursue such research interests in this time frame.

Even political policies that might be deemed irrelevant to science actually stymie the field quite markedly. Take the current hot-topic of U.S. immigration

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as an example. While immigration restrictions and firm visa requirements might be necessary to ensure the safety of the American people, they do more harm than good for American science. For many decades, the United States has relied on foreign-born scientists to help maintain its stellar scientific reputation and innovation output (*23*). Currently, foreign-born scientists contribute disproportionately to triadic patents originating from United States. Not only are there more patents originating from foreign-born scientists, but the quality of these patents are disproportionately superior and more likely to be commercialized. Consequently, foreign-born scientists in America contribute more than their share to American innovation both in scientific quantity and quality (*24*). Therefore, one would naturally assume that America would strongly encourage and even facilitate the immigration process for foreign scientists. However, the road to becoming a top scientist is not an easy one, particularly for foreign-born researchers wishing to contribute to science in America. While foreign-born researchers are clearly a lucrative asset to American science, many top foreign-born scientists face a tedious, year-long US visa application process (*23*). Political tactics put forth by the American government after the September 11th attacks, with the goal of making the United States a more secure country, are backfiring in the scientific community. The 2001 PATRIOT act, the Enhanced Border Security and Visa Entry Reform Act, and the Visa Mantis program have all contributed to a decrease in H-1B visas available for non-US born scientists who wish to bring their talents to the American scientific market (*24*, *25*). There is also a qualitative consequence to these political motions; they increase hostility of Americans towards immigrants, and foreign scientists in turn are less willing to immigrate to a country where they will face discrimination. In fact, trends in international student populations reflect changes in the political climate between the United States and other nations (*14*).

Disruption of studies is another main concern for foreign-born scientists who come to the United States seeking an undergraduate or graduate education. A student in my lab was stuck in Russia, his home country, for a solid three months waiting for his visa to clear. If American graduate students hesitate to participate in a 10-week international research programs from fear of disrupting their graduate studies, imagine the frustration of international students who become unwillingly cut-off from their American labs while stuck in the unnecessarily complicated process of renewing their visas. Perhaps the United States could take pointers from other countries; countries that face a similar dilemma of balancing their immigration laws to maximize scientific workforce flow without compromising national security. For example, another top recruiter of foreign talent, the United Kingdom, has instigated a "points" method that streamlines the visa process for talented workers before they even find a position in the U.K. (*26*). If the United States isn't quick to reform immigration policies, we may very soon lose the bulk of our scientific community- one that has allowed the United States to become the science powerhouse it is today.

Despite these political barriers, thankfully, we do still see an influx of foreign talent into the United States. However the efflux of American cross-cultural exchange remains stagnant at best. As a leader of the scientific community, the United States needs to push for internationalization of its academic curricula in

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the sciences, as it has for other areas of study. By refusing to step out of our national borders, American science is setting a poor example for both its students and also for international members of the scientific community. In doing so, we send a message that our science is self-sufficient, and that we are not willing to make efforts to step out of our home country to help science move forward. As a scientific leader, the United States is also left with many responsibilities, such as pushing for equality of international information sharing despite political tensions between countries. The United States should also do more to help developing nations become more active in science. Some steps to this end are being taken. Top scientific entities, such as Nature magazine, are working for the expansion of science to all corners of the world. Nature has recently launched several regional science websites such as Nature Middle East, Nature Asia, and Nature India (*27*). Facilitating access to scientific information will make scientists in these nations more willing and able to contribute to science-specific processes that need to be streamlined at the international level, processes such as peer-review.

Economic barriers are another unfortunate barrier to scientific international exchange. In certain cases, particularly for American scientists pursuing scientific experiences in countries that are not as developed as the United States, one must be sensitive to the confines imposed on scientific progress by economic limitations. Financially speaking, certain nations and their scientists may not be able to support research projects requiring expensive technologies. In this way, availability of funding for certain areas of research can severely limit the kinds of scientific questions that can be posed.

Economic limitations may also limit the level of scientific exposure students in these nations are able to receive. I recently gave a seminar on my research to students and faculty at *La Universidad Mayor de San Andrés* in La Paz, Bolivia. Despite being the top post-secondary institution in Bolivia, resources for students are relatively scarce. Above all, these students lack access to information on how to pursue scientific careers, and know relatively little about groundbreaking scientific advances being made in first tier research institutions. Despite these unfortunate differences, I believe that scientific communication with such nations is imperative. It is a responsibility which first-tier research institutions must undertake, lest we sacrifice the latent scientific contributions of their talented resident scientists.

Lastly, the most directly influential barrier to cross-cultural exchange in the sciences is the incongruity between science as a field of study, and science administration. Science is arguably the most universal field that exists today, being dictated by natural laws that do not vary across national and cultural borders. For that reason, it is also the field that would benefit most from internationalization. However, many of these difficulties originate from the science policy side of the table. Science education administrators need to eliminate the logistical hurdles science students face to study abroad.

As an undergraduate student, I completed two majors in the sciences: a Bachelor of Science in chemistry and a Bachelor of Arts in physics. My undergraduate institution, UNC Chapel Hill, offered an exchange program for science students called the Trans-Atlantic Science Student Exchange Program (TASSEP), in which I participated for a semester. UNC Chapel Hill is renowned

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for its undergraduate study abroad programs, boasting a 36.7% undergraduate study abroad rate. This is over 180 times the national average, making UNC the public university with the highest study abroad rate in the United States (*14*, *28*).Yet despite these encouraging statistics, I did not personally know a chemistry or physics student other than myself who studied abroad during their undergraduate years, while students in other fields studied abroad in herds. I encountered the same type of resistance while trying to encourage fellow graduate students in the sciences to consider international graduate research programs such as EAPSI.

What effect will these shocking discrepancies have on the future of science in America? Perhaps restructuring the field to include international exchanges, not unlike other fields have done, would go to great lengths in providing today's science graduate students with the international foundations they need to be maximally productive in this globalized society. At the level of science education, both at the undergraduate and graduate levels, restructuring academic tracks to include international exchanges (or at least facilitate them) would help incorporate elements of internationalization into students' curricula. Science as a field of study is unique in that it necessitates a "vertical" learning approach such that science courses *must* be taken in a certain sequence, cell biology preceding genetics, or differential equations preceding nonlinear dynamics and chaos. Other fields of study are more lenient in defaulting to a "horizontal" learning approach. Anthropology of indigenous societies need not precede sociology of Eastern European immigrants. Not having been exposed to the literary works of Henry David Thoreau won't impair your ability to study Shakespeare. This is an unfortunate fact of life for the internationalization of science education, because curricula for vertically learned subjects are consequently inflexible and therefore less amenable to the incorporation of study abroad components.

The incorporation of study abroad into science could be accomplished by working more closely with international post-secondary institutions to ensure that course credits students take abroad will transfer seamlessly onto their home institution transcripts. Another option would be to copy what other fields of study have done to ensure their students complete essential parts of their curricula in a timely manner, and gain experience learning and living in an international setting. For example, the University of Chicago's Booth school of business has expanded its campus to Barcelona, Spain, where it has a branch campus offering a University of Chicago MBA. This ensures that students are able to follow curricula set forth by the University of Chicago, and receive degrees from their home institutions while expanding their intercultural knowledge. Furthermore, schools in other nations are increasingly seeking American accreditation. Having American accreditation might help these schools to adopt curricula that are similar to those followed by American schools, and could facilitate international exchanges (*14*).

All of these barriers will be present, to varying extents, during an international research experience. For example, each of the seven locations offered by the EAPSI program varies in terms of political and economic standing. As a visiting student to some of these locations, one must be sensitive to the fact that certain nations may not be able to provide their scientific community with a level of

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funding to which you may be accustomed. Therefore, expecting these laboratories to provide you with certain equipment during your research experience may be unreasonable. Nevertheless, a positive research experience abroad depends much more on your personal motivation to succeed both in and out of lab, than on the types of instruments you are using. After all, the greater the dissimilarity between your home and host laboratory environments, the more rewarding the international experience will be as a learning tool for your career. Simply by taking the initiative to study abroad, despite all of the existing barriers to cross-cultural exchanges, you are already doing your part to help lower these barriers for future generations of scientists.

As American graduate students in the sciences, we need to realize that we becoming are part of a top-notch scientific community with an obligation to break down the barriers that are hindering universal scientific progress across national borders. Even as a graduate student there is much you can do, such as participating in international research programs like EAPSI, or taking the opportunity to visit local universities and science institutions during your international vacations. We must as a nation facilitate the process of international exchange, both for our own students of science and for foreign-born scientists wishing to study in America. We must amend our views and our actions as scientists in a manner that breaks down or works around political, cultural, socio-economic, and national barriers to scientific progress to create an environment in which science can thrive freely. Action must be taken, otherwise there will be no future for scientists that are being excluded from this globalized world, and the scientific community which knows no national boundaries will be deprived of their latent scientific contributions.

Final Remarks

It is evident that the barriers which continue to plague science are not problems that will be solved without collaborative effort from all members of the scientific community. Programs such as EAPSI are offered to encourage future generations of scientists to engage in collaborative research and open doors for scientific relationships that will strengthen ties between the United States and foreign scientific entities. By participating in such programs, you will gain both tangible (financial support, new professional networks) and intangible (personal growth, better world viewpoints) benefits that will help propel the future of science. Furthermore, professional international experiences will put you in a better position to help contribute to the solutions for the barriers to cross-cultural exchange. It will take efforts on behalf of all scientists to break down barriers that hinder scientific progress, and going abroad is an enormous first step. Going abroad will help you identify and actually encounter some of the barriers that are prevalent in science, which will make you more aware of how to approach science more effectively. There are also many other ways to approach these barriers that extend beyond the scope discussed in this chapter. You could try to bridge the gaps between elementary and higher education in the sciences by mentoring science-driven students through these transitive years. You can get more involved in the political workings of your community and push for the reform of policies

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that currently limit the advancement of science. You could even work with a choreographer to put together an interpretative dance of your research to help bridge gaps between science and the arts (*29*)! There is no better way to start your career as a scientist than by becoming involved in the amelioration of the field, particularly during your graduate studies.

The Japanese have a popular expression, "gambatte", which is known as "good luck" here in the United States. However, the meaning of "gambatte" is slightly more complex. It means to try one's best regardless of the result, encompassing the essence of Japanese culture and way of life. I encourage all scientists, from graduate students to fully tenured professors, to take it upon themselves to expand their cultural and scientific horizons through internationally collaborative science to the best of their abilities. After all, in the words of Mark Twain, "twenty years from now you will be more disappointed by the things you didn't do than by the ones you did do... Explore. Dream. Discover." 頑張って!

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